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Review on the Environmental Impacts of Municipal Solid Waste in Nigeria: Challenges and Prospects

By

**Tariwari C. N. Angaye
Jasper F. N. Abowei**

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***Tariwari C. N. Angaye and Jasper F. N. Abowei**

Department of Biological Sciences, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria.

*Corresponding Author's E-mail: maktarry@yahoo. Com; Mobile: +2347037889063.

ABSTRACT

This review provides insight on the environmental impacts of municipal solid wastes (MSWs) in Nigeria. The anthropogenic impacts of waste streams that infringes on ambient air quality, both ground and surface water, soil as well as biodiversity in dumpsites are discussed. The precarious generation of large waste stream whose leachates and effluent contaminate the environment is largely due to lack of sensitization, poor legislation, population expansion, industrialization and inadequate funding of the sector by Government. Besides the adverse impacts on various forms of biodiversity, Poor management of waste have the ability to limit aesthetic values of vital resources in the ecosystem, thereby increasing the incidence of global warming. An Integrated approach has become necessary for the efficient, safe and effective management of MSW, including more efforts by; individual effort, Local, State and Federal government, and the role of other stakeholders, pressure groups in the private sector are paramount.

Keywords: MSW, Air quality, Water, Soil, Pollution, Leachate.

1.0 INTRODUCTION

The problems posed by improper and ineffective management of Municipal Solid wastes (MSWs) has become an issue of global concern over the past decades. The magnitude of waste stream has acquired some abrupt dimensions (Schwarz-Herion, 2008; Amuda *et al.*, 2014), with corresponding ineffective and inadequate management strategies (Angaye *et al.*, 2015a), including insufficient funding on the part of Government (Doan, 1998; Hossain *et al.*, 2014). The incidence of poor waste handling that has infringed on vital environmental components; including but not limited to soil, water and to air quality. Also, the magnitude of commercialization, industrialization and population expansion of most cities all over the world has also had its attendant adverse effects on the environment (Abur *et al.*, 2014).

In Nigeria, statistical data as reported in literature by Ayuba *et al.* (2013) showed that municipal waste density ranges from 280 - 370 kg/m³, while the rate of daily waste generation is about 0.44 - 0.66 kg/capital/day (Ogwueleka, 2009), with an annual generation of 25 million tons. Furthermore, as documented in literature, Nigerian urban population has witnessed a remarkable abrupt growth due to rural-urban migration (Adejobi and Olorunnimbe, 2012), largely necessitated by yearning of the populace to keep abreast or understand contemporary technological applications. Unfortunately, high population density is implicated in poor handling of large waste streams generated, due to inadequate waste facilities and consequently results to environmental pollution. In most developing countries, anthropogenic activities associated with the precarious disposal of MSWs poses more grave consequences to the ecosystem, besides being threat to public health (Adamu *et al.* 2014).

The quality of very sensitive environmental media (air quality, soil and water), and keystone resource are largely infringed upon by MSWs. For instance, toxic or contaminable leachates from MSWs dumpsites could be transformed physically, chemically or biologically (Al Sabahi *et al.*, 2009), and transported via the air, or through runoffs which can contaminate either the soil, surface or/and groundwater (Christensen *et al.*, 1998; Kola-Olusanya, 2012). Also, toxic fumes and greenhouse gases are also being produced by precarious or uncontrolled *in-situ* burning (Okeke, 2014), which could have acute or chronic health and environmental consequences (Jalil, 2010; Adekunle *et al.*, 2011; Ayuba *et al.*, 2013).

According to Onwughara *et al.* (2010), the management strategies of MSWs varies per country but not limited to landfill system, incineration and recycling. They also reported that; underdeveloped nations use landfill system, while developed nations like; the United States Japan and Australia use mostly use the recycling method. Although in Nigeria waste recycling has been encouraged by all stakeholders, but unfortunately it is yet to attain full recognition due to slow implementation and insufficient funding. As such the commonest method of disposal in Nigeria still remains open dump and landfill system and *insitu* incineration (Momodu *et al.* 2011), which are very prone to environmental pollution.

2.0 MUNICIPAL SOLID WASTE

Solid wastes are referred to as unwanted or needless non-liquid substances which can be referred to as garbage or refuse as opposed to liquid waste which are called effluent. The American Public Works Association defined solid waste as needless or ready to be discarded substances with inadequate liquid component. Municipal solid waste in this context refers to solid or non-gaseous wastes arising from domestic, industrial, commercial or agriculture origin (Adedibu, 1983). It was reported by Abur *et al.*, (2014) that due to the poor management of municipal solid waste management in developing nation like Nigeria, conservation of the ecosystem and other vital resources has become a major challenge. While waste characterization is very key in efficient and successful management of municipal waste (Guadalupe *et al.*, 2009); It is noteworthy that most cities across Nigeria municipal solid waste are usually to characterised prior to their disposal, leaving their toxic and untreated components to undergo transformation thereby infringe on fragile system of the environment.

2.1. Categories of Municipal Solid Wastes

Municipal Solid waste (MSW), are referred to as ready to discarded or needless non-liquid substances or material originating from human activities, including domestic and industrial sources. Human activities create vast streams of wastes and pollutants, which are capable of infringing on vital components of the ecosystem (reference). Municipal solid waste (MSW), commonly known as trash or garbage in the United States and as refuse or rubbish in Britain, is a waste type consisting of everyday items that are discarded by the public. "Garbage" can also refer specifically to food waste, as in a garbage disposal; the two are sometimes collected separately. There are basically two sources of MSWs, which are domestic and commercial sources (Momodu *et al.*2011). Domestic Sources, refers to general household wastes which includes food waste, rubbish, ashes and special wastes. While commercial sources are referring to waste originating from commercial activities like restaurants, shops, auto-mechanic repairs, medical facilities, schools, construction activities and other special wastes (references). Furthermore, wastes may be classified according their source, properties, degradability, toxicity. Classification based on point source is presented in Table 1 below:

Table 1: Classification of Solid Waste based on Source

S/N	Classes of Waste	Characteristics and Possible Source	Typical Examples	References
1.	Household Solid waste	Specific solid wastes originating from Domestic activities	Food items, clothes, damage utensils, ashes, garden waste	NEST 1991; 1995; Anyakoha and Egboeli; 1993
2.	Organic Waste	Solid biodegradable waste	Leaves, vegetables, fruits, food scraps, carcass, wood etc.	NEST, 1991; Adamu <i>et al.</i> 2014
3.	Plastic waste	Usually semi-degradable or non-degradable	polythene bags, package water bags, plastic products, used tyres, old electrical appliances, phone casing etc.	NEST, 1991; Botkin and Keller, 1997
4.	Metal waste	Metallic waste recalcitrant, could be toxic due to their leachability to the environment	buckets, spoons, plates, pots, pans, sinks, poles, scrap cars, refrigerators, generators, air conditioners, empty tins etc.	NEST, 1991; Adamu <i>et al.</i> 2014
5.	Glass	These are made up of broken or discarded glassware	Drug, wine and chemical bottles container, broken windscreen, ceramic plates and cups, empty bottles of drugs, chemicals, drinks	Botkin and Keller, 1997; NEST 1991

2.2 Process of Municipal Solid Waste Management in Nigeria

The process of municipal waste management involves several compounding and multifaceted procedures, which includes but not limited to; segregation, packaging/storage, collection, transportation, processing, resource recovering, recycling and disposal (Abila and Kantola, 2013; Oyekan and Sulyman 2013). Notwithstanding, the commonest method of waste disposal, the commonest are landfill system, incineration, composting and anaerobic digestion and recycling (Igbinomwanhia, 2011). Unfortunately, in most developing nations adherence to this procedure are not wholesomely adhered to, as wastes are usually dumped precariously in the bush or along the road. A study in 2003 by the health and Demography department of Nigerian National Population Commission indicated that only 14% of Nigerian have access to reliable household waste disposal system. It was also documented in literature that about 87% of Nigerian allegedly used unsanitary disposal system (Oyekan and Sulyman, 2015). These wastes could be transported by runoff during precipitation into pits and drainage

(Babayemi and Dauda 2009; Onwughara *et al.* 2010), or even infiltrates through the soil which they constitute major environmental problems like groundwater pollution (Kola-Olusanya, 2012). The volume of waste generated is largely attributed to several compounding factors which includes; population density, income, industrialization, attitude and legislation of the catchment area (Adedibu, 1985). For instance, Abila and Kantola, (2013), reported that the quantities of MSW generated in rural communities are usually less and better managed compared to urban communities, for instance household waste are usually incinerated or used to feed domestic animals.

Figure 1: Estimated volumes of Municipal solid waste generated in some Nigerian cities

Besides the fact that there are lesser technological and industrial activities in rural settings, waste generated in rural communities are often degradable or by products of agricultural origin. Unfortunately, due to maintenance cost, inadequate sensitization on danger posed and poor legislation, the commonest method of waste disposal and management in Nigeria has become, open dumping, landfill. The application of landfill system could envisage some environmental impacts which could be mitigated by adherence to aseptic and precautionary measures (Abila and Kantola, 2013). For instance, it was established in literature by Burney *et al.* (2011), that 49% of England's methane emissions in 2007 were largely attributed to landfills system of waste disposal. Efficient and effective waste management in Nigeria should be implemented without much ado, this is broadly dependent on the three Rs policy (Reduce, Re-use, Recycle). In Nigeria, there is no formal recycling sector as solid waste, which majorly includes scrap metals and plastic are usually selectively recycled by scavengers based on their economic value.

Table 2: Percentage composition of Municipal Solid Waste in Some Major City Across Nigeria

State	Garbage/Food (%)	Nylon/Plastic (%)	Paper (%)	Metal (%)	Glass/Ceramic (%)	Others (%)	Reference
Abuja (FCT)	53.80	7.04	9.58	2.54	7.32	20.28	Abur <i>et al.</i> , (2014)
Akwa Ibom	49.60	7.72	3.13	6.07	-	5.33	Okey <i>et al.</i> , (2013)
Ilorin	11.15	15.80	8.81	-	-	64.23	Ahmed (2012)
Kano Metropolis	41.50	21.50	23.00	14.00	-	-	Nabegu, (2010; 2014)
Edo State	46.53	26.32	14.77	3.32	8.16	0.93	Igbinomwanhia, (2012)
Jigawa State	60.58	5.95	7.01	12.17	14.29	8.06	Musa <i>et al.</i> , (2016)
Enugu State	46.16	35.32	10.17	6.84	2.57	11.92	Ugwuishi, <i>et al.</i> , (2016)
Akwa Ibom State	63.88	11.32	4.58	4.58	3.50	29.00	Okey <i>et al.</i> , (2013)
Abuja Municipality	54.96	20.22	12.84	5.84	4.38	1.63	Ayuba <i>et al.</i> , (2013)
Kwara State	11.21	15.79	8.80	-	-	64.19	Ahmed, (2012)
Nasarawa State	27.00	8.00	2.00	6.00	10.00	47.00	Anyawu and Adefila, (2014)
	34.00	8.00	4.00	8.00	10.00	36.00	
	32.00	8.00	4.00	6.00	7.00	43.00	
	33.00	4.00	4.00	6.00	12.00	59.00	

2.3. Sources and Fate of Municipal Solid Wastes

Environmental pollution caused by municipal solid waste is mostly caused by human anthropogenic activities including quest to adopt contemporary technologies, urbanization, industrialization, with a corresponding inefficient waste management strategies (Rajaganapathy, *et al.*2011). Sources of contamination include: spills during transportation, poor containment of waste, surface runoff, uncontrolled *insitu* burning, inability to segregate waste, impromptu disposal of waste, siting of dumpsites close to water way and residential area etc. (Worksafe, 2005; Shayley *et al.*2009; Stavrianou, 2007). In addition, some of the populace lack technical know-how and personal orientation on the envisaged danger of precarious dumping of waste. It was documented in literature that the toxicity and fate of pollutants released from human activities is largely dependent on the source and target (Shayley *et al.*2009), as well as its leachability to the environment. Notwithstanding, there are several routes of exposures which includes inhalation, oral ingestion, eye or dermal contamination or through other human body orifices.

Furthermore, the adverse effects of any pollutant are largely dependent on its toxic properties, including the exposure rate and concentration of the toxicant (Stavrianou, 2007). Leachates from dumpsites can be transported by runoffs to contaminate either soil or other sources of water, thereby posing danger to species which depends on such water resources. Fate of contaminants can be intensified by certain compounding or synergistic factors including soil porosity, permeability, mineralogy, pH, organic matter, moisture, temperature etc (Shayley *et al.*2009). It is also worthy of note that bioavailability also play vital role in the fate of some contaminants, for instance certain biodegraders might by synergistic with toxic waste or on the other hand mitigate their toxicity. For instance, in aquatic ecosystems, recalcitrant waste toxicant like heavy metal are usually soluble or suspended in water and their persistence will make them settle to the basal zone where they are bonded with sediment, and other forms abyssal biota (Aderinola *et al.*2009; Ene *et al.*2009; Obodai *et al.*2011).

3.0 ENVIRONMENTAL IMPACTS OF MUNICIPAL SOLID WASTE IN NIGERIA

3.1. Some Environmental Aspects of Solid Waste in Nigeria

3.3.1. Environmental Degradation

Environmental degradation is inevitable, when there is unsafe and precarious dumping of untreated MSWs on fragile components of ecosystem, as well as the corresponding attendant effects physicochemical and natural agents that transform waste. Furthermore, the persistent accumulation of toxic and recalcitrant wastes on land pollutes the environment and further limits its application (Singh, 1998; Akinjare, 2011). In addition, MSW could limit the aesthetic values of key resource in the environment. For instance, MSWs have the ability to plug drainage channels which can lead to excessive flooding during precipitation (Oyekan and Sulyman, 2015). Also, solid waste dumping is an eyesore which limits the accessibility, and alters the comfort, habitability and attractiveness from its normal state (Oyediran, 1995). Also, the incidence of ground water pollution as a result of poor waste landfill system that results arising from leachate percolation cannot be overemphasized (Mor *et al.*2006). Recent literature also revealed that vegetation found in dumpsites have the ability to bioaccumulate anthropogenic agent. To a great extent unregulated dumping also limit soil productivity for agrarian purpose (Anikwe and Nwobodo, 20002)

3.3.2. Environmental Pollution

Solid degradable waste in synergy with environmental factors and bio-degraders or both comes with environmental impacts that limit the quality of air, soil, as well as both surface and ground water. For instance, under anaerobic condition methanogens (bacteria) can aid the release of methane gas (Amuda *et al.*2014), as well as CO₂ or both (Nayono 2010; Lam and Lee, 2011; Ohimain and Izah, 2017), which degrade air quality and also aid the incidence of global warming. Besides this, other anthropogenic pollutants associated with MSWs pollutants including greenhouse gases such as: carbon dioxide, methane, oxides of sulphide, nitrogen; as well as heavy metals which includes but not limited to; Cadmium (Cd), Copper (Cu), Iron (Fe), Lead (Pb), Zinc (Zn), Aluminium (Al) are transported as leachate through the soil to underground water, or as runoff from one ecosystem to the other during precipitation which they could be biomagnified along the food chain by aquatic and terrestrial biota thereby resulting to pollution that induce adverse effect (Walker and Colwell, 1974). In a developing country like Nigeria, high MSW stream are generated with corresponding inadequate management strategies (Angaye *et al.*2015), largely due to financial constrains (van Beukering *et al.*1999; Omaran and Gavrilescu, 2008; Onwughara *et al.*2014) or weak legislation (Nkwachukwu *et al.*2010), thus resulting to the practice of open air *insitu* burning which have attendant greenhouse effect that results to global warming (Ayuba *et al.*2013; Amuda *et al.*2014).

3.3.3. Health consequences

Illicit open of dumping of MSWs comes with grave health consequences due to the fact that dumpsites provide substrate for breeding, feeding and habitation of pathogenic organisms and vectors of public health importance. Oyekan and Sulyman (2015), reported that insects and vectors that transmits major diseases of public health are usually found in dumpsites. These vectors include but not limited to flies, mosquitos and rodents (Onibiokan, 2000). For instance, the breeding of flies is decomposing of organic waste, while mosquitoes are encouraged by piles of refuse like, car tyres, empty cans etc., these vectors play vital roles in the transmission of disease of public health importance like plague, amoebic dysentery, rat bite fever, Lassa fever etc (Barina, 2003; Adamu *et al.*2014). Vegetation grown in contaminated soil have the ability to bioaccumulate toxic heavy metals, in their tissues which pose potential health risks as they could biomagnify in the consumer's tissue (Onwughara *et al.*2014).

3.4. Impact of MSW on Air Quality

As presented in Table 3 below, literature survey of air quality around Nigerian MSW dumpsites showed that values exceed threshold limits of the Federal Environmental Protection Agency. These is largely attributed to unsafe management of MSW including uncontrolled open air *insitu* burning of waste, whose direct effects on biodiversity and greenhouse effect cannot be overemphasized. Statistical data based on mortalities attributed to air pollution and the synergistic role they play in the development of respiratory diseases (Barakat-Haddad, 2015), the World Health Organisation has recently identified air pollution as a basic health hazard (WHO, 2014). The generation and poor management of MSWs in Nigeria comes with adverse attendant environmental and health effect. Air Pollution associated with solid dumpsites has become a major source of concern due foul odour released and the emission of greenhouse gases like: carbon monoxide, oxides of Nitrogen and Sulphur as well as release of suspended particulate matter during *insitu* burning (Lingan, *et al.*2014).

Furthermore, it was reported in literature that inadequacies in efficient waste management of most developing nations had impair human health and biodiversity with corresponding adverse effects on keystone resources (Sharholy *et al.*2008). For air quality pollution, the major route of exposure is by the process of inhalation (Barman, *et al.*, 2010). Notwithstanding, air pollution can cause nasal, eyes and airway irritation, wheezing, coughing, anoxia, and even lung and heart problems, which increase risk to asthma and heart attack. Whereas in extreme cases it can result to mortality, the chronic exposure to air pollution can compromise the immune system and cause systemic cancer of the nervous, reproductive, and respiratory systems. Presented in Table 3 below are data of air quality around some MSW dumpsites in Nigeria.

Besides toxic emission during burning of waste, suspended particulates matter release contain anthropogenic substance which can carcinogenic, irritate the nasal cavity or the lungs and cause infections ranging from cold to other air-borne diseases (Bency *et al.*2003; Lingan *et al.*2014). Another report indicated that people whose abode are close to dumpsite are predispose to cardiovascular diseases (Nautiyal *et al.*2007; Barakat-Haddad, 2015), like bronchitis, lung cancer, cardiovascular disease, birth defect, asthma, and premature mortalities (Agwu and Ozeh, 2013). Another study on the relative aerobic microbial distribution of a dumpsite in Nigeria showed, 37% *Escherichia coli*, 19% *Klebsiella* spp, 13% *Pseudomonas* spp, 15% *Serratia* spp, 8% of *Staphylococcus* spp, 7% of *Enterococcus* spp, with the least being 1% of *Salmonella* spp. (Odeyemi, 2012).

Table 3: Air Quality Assessment around Some MSW Dumpsite in Nigeria

State	Temp	RH	H ₂ S (ppm)	SPM (ppm)	CO (ppm)	SO _x (ppm)	NO _x (ppm)	NH ₃ (ppm)	CH ₄ (ppm)	VOC (ppm)	Reference
	30 °C	NA	NS	250µg/m ³	10.0-20.0 ppm	0.01-0.10 ppm	0.04-0.06 ppm	NS	NS	NS	FEPA, (2001)
Imo State (Morning)	-	-	0.80-0.84	6.30 - 6.80	0.28-0.31	0.09-0.13	0.08-0.11	0.06-0.10	0.12-0.14	-	Ubouh <i>et al.</i> (2016)
Imo State (Evening)	-	-	0.79 -0.82	6.57	0.20 -0.24	0.11	0.07-0.10	0.05-0.09	0.09-0.12	-	
Rivers State	28.0-30.8	62.6-68.40	0.06	-	-	0.230	0.037	0.000	0.06	-	Weli <i>et al.</i> (2014)
Abia State	-	-	-	-	-	-	0.02 - 0.09	-	-	-	Nwakanma <i>et al.</i> (2016)
Niger Delta States	-	-	3.40 - 7.70	773 - 801	133.7-141.6	27.7 - 37.1	21.0 - 27.3	14.7 -19.5	2310 - 2771	-	Rim-Rukeh, (2014)
Ebonyi State	-	-	0.03-0.07	-	1.74 -1.90	-	0.05 -0.12	0.047-0.070	-	-	Njoku <i>et al.</i> (2014)
Rivers State	-	-	-	-	0.00-4.00	<0.01	4.40 -6.50	1.00-1.20	-	0.40 - 1.30	Ezekwe <i>et al.</i> (2016)
Kaduna (Dry Season)	-	-	0.00135 - 0.0315	-	1.500 - 11.40	0.0005 - 0.0032	0.00605	-	-	-	Uba (2015)
Kaduna (Wet Season)	-	-	0.0005 - 0.0037	-	1.50 - 10.50	0.0011- 0.0390	0.00185- 0.00365	-	-	-	

The environmental impacts of MSW on water and soil quality cannot be overemphasized, although soil texture and structure determines the degree of percolation. Ogedengbe and Akinbile (2007) reported that high degree of turbidity in ground water samples from dumpsites is due to the percolation of leachate. In the review results as reported by several authors indicates that most ground water located in dumpsites are contaminated, with values exceeding regulatory limits. In the same vein, higher level of heavy metals which contaminates groundwater have also been reported (Akpan, 2004; Bahnasawy *et al.* 2011). Due to the solubility of these contaminants (Udoessien, 2004), they become persistent and accumulate to cause various adverse effects. As reported by Iwuoha *et al.* (2013), in surface water and sediment organic matters play vital regulatory role in determining heavy metal distribution. This is because they bind with heavy metals by the process of adsorption to form solution. Notwithstanding, the availability is dependent on some physicochemical factors including; temperature, pH, hardness, exposure rate etc (IPCS, 2003; WHO, 2003). Some microbes of medical importance such as *E. faecalis* and *E. coli* have been isolated from ground water close to dumpsites in Nigeria, these strains of pathogen were reported to be resistant to some first line antibiotics (David and Oluyeye, 2014).

As presented in Tables 4 and 5 below result of some physicochemical and heavy parameters as reported by the authors showed that both surface and ground water quality as well as soil around MSW dumpsites exceeds regulatory limits as stipulated by Nigerian Standard for Drinking Water Quality. These have been largely attributed to leachate percolation and transportation through surface runoff during precipitation (Angaye *et al.* 2015; 2016; Adebara *et al.*, 2016). Varying concentrations of some heavy metals have been found in both soil and water samples collected from dumpsites including; Zinc, Lead, Manganese, Chromium, Copper, Cobalt, Mercury (Akinbile and Yusoff 2011; David and Oluyeye, 2014; Adebara *et al.*, 2016). Due to the fact that heavy metals are usually persistent and recalcitrant to degradation, they remain in the soil or water body where they are bioaccumulated and move from one trophic level to the other. For instance, Izah and Angaye (2016) reported that fishes have the ability to bioaccumulate heavy metals originating from waste stream. In terrestrial ecosystem plants were also reported to bioaccumulate heavy metals from soil in waste dumpsites, these heavy metal pollutants were reported to have limited the growth rate of phyto-diversities (Eshalomi-Mario and Tanee, 2015). Also vital mineral content like chlorophyll and ascorbic acid content of phyto-diversity of MSW have been limited due to pollution (Falusi *et al.* 2016).

Table 4: Physicochemical Quality of Groundwater Around Some MSW Dumpsite in Nigeria

State	Source	Temp. (°C)	pH	Cond (µs/cm)	DO (mg/l)	Turbidity (mg/l)	TSS (mg/l)	TDS (mg/l)	Hardness (mg/l)	Sulphate (mg/l)	Nitrate (mg/l)	Reference
NSDWQ Limits	NA	Ambient	6.50-8.50	-	-	5.00	-	500	200	-	50	NSDWQ (2007)
Cross River	GW	26.45-27.28	5.50-6.61	169-564.95	5.01-11.68	-	0.02-0.62	47.32-211.70	-	-	-	Udofia <i>et al.</i> (2016)
Osun State	GW	27.4-31.5	7.5-10.8	70-364	-	-	-	49-248.2	-	-	-	Oyelanmi <i>et al.</i> (2013)
Ekiti State	GW	-	5.86-7.84	12.2-23.4	-	1.0 – 8.0	181.6 – 272.2	-	324.6-456.3	235.0-522.0	13.0 - 38.0	David and Oluyeye, (2014)
Niger State	Wet	-	7.24-8.41	344-1-91	3.66-8.78	4.48-37.70	-	230.98-730.97	-	-	-	Sadiu (2011)
	Dry	-	7.82-8.41	501-1191	3.70-9.50	5.50-38.70	-	21.00-738.99	-	-	-	
Ogun State	-	-	6.74-7.59	148-784	-	-	-	88-392	26-288	13.39-144.03	1.36-4.81	Badmus <i>et al.</i> (2015)
Ondo State	GW	26.50-27.50	5.68-6.82	-	0.90-2.40	1.60-6.60	-	18-342	-	-	30.0 -61.0	Akinbile and Yusoff (2011).
Osun State	GW	26.30-29.60	5.90-7.10	125.00-464.00	2.10-5.20	2.51-8.60	-	-	-	-	0.05-3.60	Adebara <i>et al.</i> (2016)
Lagos State	GW	-	5.01-5.67	-	-	-	-	-	-	-	-	Salami <i>et al.</i> (2014)
	SW	-	6.20-6.24	-	-	-	-	-	-	-	-	
Kaduna State	GW Dry	-	6.21- 6.91	-	1.51-1.71	-	-	73.40-720.00	251.40-646.40	-	-	Okpanachi, (2012)
	GW Wet	-	5.97 – 6.72	-	1.32	-	-	107.40-710.00	253.40-655.0	-	-	
Bayelsa State	SW Dry	28.7-30.5	7.40-7.57	78.33-89.33	1.76-5.68	11.67-19.67	-	55.00-62.00	3.27-5.27	1.98-2.66	-	Izonfuo and Bariweni, (2001)
	SW Wet	27.3-29.3	6.9-7.33	47.73-54	1.38-9.06	16.67-28.00	-	33.00-37.83	2.27-3.36	2.22-6.27	-	
Rivers State	-	-	6.10-6.80	24.00	5.60-11.30	0.003-0.04	80.00-81.70	-	4.00-5.05	-	-	Iwuoha <i>et al.</i> (2013)
Akwa Ibom	GW Dry	25.80-26.53	5.40-5.67	42.33-58.90	5.43-5.77	0.62-0.77	0.36-0.44	49.47-53.30	-	-	-	Monechot, (2012)
	GW Wet	23.70-25.30	5.54-6.09	39.97-62.90	5.13-6.10	0.45-1.25	0.31-0.45	42.85-59.30	-	-	-	

SW: Surface Water, GW: Ground Water.

Table 5: Heavy Metal assessment of Groundwater and Surface around Some MSW Dumpsite in Nigeria

State	Source	Hg (mg/l)	Pb (mg/l)	Cr (mg/l)	Cd (mg/l)	Cu (mg/l)	Zn (mg/l)	Mn (mg/l)	Fe (mg/l)	Co (mg/l)	Reference
NSDWQ Limits	NA		0.01	0.05	0.05	1.00	3.00	0.20	0.5-50		NSDWQ (2007)
Cross River	GW	-	0.005-0.07	-	0.007-0.030	0.66-3.01	0.97-4.08	-	-	-	Udofia <i>et al.</i> (2016)
Ekiti State		0.00 - 0.01	0.01 - 0.13	-	-	0.01 – 0.10	0.19 – 2.95	-	-	0 – 0.10	David and Oluyeye, (2014)
Osun State	GW	-	<0.001	<0.001	<0.001	<0.001	0-0.041	0-0.57	0-1.36		Oyelanmi <i>et al.</i> (2013)
Ondo State	GW	0.90-1.40	0.01-1.21	0.001-0.25	-	<0.001	0.30-2.30	0.001	0.90-1.40	-	Akinbile and Yusoff (2011)
Osun State	GW	-	-	0.00-0.002	-	0.00-0.005	0.001-0.040	0.00-0.006	0.01-0.08	-	Adebara <i>et al.</i> (2016)
Lagos State	GW	-	0.001	0.001-0.010	0.001	0.009-0.010	0.049-0.086	0.010-0.016	0.098-0.129	-	Salami <i>et al.</i> (2014)
	SW	-	0.00	0.04-0.011	0.00	0.014-0.019	0.074-0.096	0.014-0.019	0.089-0.108	-	
Kaduna State	Dry	-	0.001-0.096	0.004-0.026	-	-	0.006-0.012	-	0.100-0.210	-	Okpanachi, (2012)
	Wet	-	0.001-0.036	0.005-0.030	-	-	0.0062-0.014	-	0.139-0.310	-	
Akwa Ibom State	Dry	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.11-0.15	0.33-0.36	-	Monechot, (2012)
	Wet	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.01-0.04	0.03-0.08	-	

SW: Surface Water, GW: Ground Water.

Table 6: Soil Quality Around Some MSW Dumpsite in Nigeria

State	pH	Cond μs/cm	Pb (mg/kg)	Cr (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Reference
Bayelsa State	7.60	-	14.75-16.14	0.05 - 0.06	<0.0001	-	-	-	-	Amos-Tautua <i>et al.</i> (2013)
Imo State	4.82-5.10	186 - 200	10.80-12.50	-	0.18-0.21	21.00-33.50	78.20- 96.50	18.20-27.14	-	Amadi <i>et al.</i> (2012)
Ebonyi State	-	-	63.40-72.10	-	-	22.50-31.00	62.70-68.50	-	423.00-430.30	Anikwe and Nwobodo, (2001)
Lagos State	7.90-8.00	-	<0.001-0.900	12.10-16.20	13.20-13.90	307.3-404.8	110.3-113.7	-	-	Oluseyi <i>et al.</i> (2014)
Bauchi State	-	-	4.31-10.63	5.04-8.31	0.21-1.21	0.79-2.07	-	-	-	Buteh <i>et al.</i> (2013)
Ondo State	-	-	24.7-59.70	-	-	31.7-101.9	-	-	-	Akinbile, (2012)
Ebonyi State	-	-	12.80-14.35	-	0.65-0.80	3.60-4.30	-	-	-	Njoku <i>et al.</i> (2014)
Lagos State	5.65-5.69	-	0.019-0.029	0.269-0.0279	0.000	2.70-3.01	11.980-12.460	5.981-6.700	37.475-39.650	Salami <i>et al.</i> (2014)

Table 7: Microbial Diversity of some MSW Dumpsites in Nigerian

Species	Odeyemi, (2012)	Ambrose <i>et al.</i> (2015)	Oluseyi <i>et al.</i> (2014)	Ogunmodede <i>et al.</i> (2014)	Nagadu, (2010)
BACTERIA SPECIES					
<i>Escherichia coli</i>	-	+	+	-	+
<i>Bacillus spp.</i>	-	+	+	-	-
<i>Staphylococcus spp.</i>	+	+	+	-	+
<i>Salmonella spp.</i>	+	-	-	-	+
<i>Micrococcus spp.</i>	-	+	-	-	-
<i>Enterococcus spp.</i>	+	-	-	-	-
<i>Pseudomonas spp.</i>	+	-	-	-	-
<i>Klebsiella spp.</i>	+	-	-	-	+
<i>Shigella spp.</i>	-	-	-	-	+
<i>Lactobacillus spp.</i>	-	-	-	+	-
<i>Serratia spp.</i>	+	-	-	-	-
<i>Proteus Spp.</i>	-	-	-	-	+
FUNGI SPECIES					
<i>Aspergillus spp.</i>	-	+	+	+	+
<i>Penicillium spp.</i>	-	+	+	+	-
<i>Fusarium spp.</i>	-	+	+	+	-
<i>Rhizopus spp.</i>	-	+	-	+	-
<i>Trichoclerna spp.</i>	-	-	+	+	-
<i>Absidia spp.</i>	+	+	-	+	-
<i>Mucor spp.</i>	-	+	-	+	-
<i>Candida spp.</i>	-	+	-	-	-
<i>Neurospora spp.</i>	-	-	-	+	-
<i>Alternaria spp.</i>	-	+	-	-	-
<i>Cephalosporium spp.</i>	-	-	-	+	-
<i>Saccharomyces spp.</i>	-	-	-	+	-
<i>Cladosporium spp.</i>	-	+	-	-	-
<i>Helminthosporium</i>	-	-	-	+	-
<i>Pullularia spp.</i>	-	-	-	+	-
<i>Triamnidium spp.</i>	-	-	-	+	-
<i>Phoma spp.</i>	-	+	-	-	-
<i>Geotrichum spp.</i>	-	+	-	-	-
<i>Zygorrhynchus spp.</i>	-	-	-	+	-

Keys: + means endemic species, - means Non-endemic or not investigated species.

As presented in Table 7, the following predominant bacteria species were reported in some MSW dumpsites in Nigeria including; *Escherichia coli*, *Staphylococcus spp*, *Klebsiella spp*, *Salmonella spp*, *Bacillus spp*, *Shigella spp*, *Proteus Spp*, *Pseudomonas spp*, *Salmonella spp*, *Lactobacillus spp*, *Micrococcus spp.*, *Serratia spp*, *Enterococcus spp*. Which fungi species associated with dumpsites are; *Aspergillus spp*, *Alternaria spp*, *Fusarium spp*, *Rhizopus spp*, *Candida spp.*, *Penicillium spp*, *Trichoderma spp*, *Triamnidium spp.*, *Neurospora spp*, *Mucor spp*, *Phoma spp.*, *Neurospora spp.*, *Geotrichum spp.*, *Cladosporium spp.*, *Cephalosporium spp*. etc. (Nagadu, 2010; Odeyemi, 2012; Oluseyi *et al.*2014; Ogunmodede *et al.*2014; Igborgbor, and Ogu, 2015; Ambrose *et al.* 2015).

3.5. The Nigerian Challenges and Prospects in Solid Waste Management

As opposed to developed nation where total recovery and recycling of waste has become a practice; the challenges associated with municipal waste management in Nigeria has become a source of concern. Although, these cases are unlimited to Nigerian urban cities as it varies geopolitically depending on sensitization of the populace (Momodu *et al.*2011), legislation, as well as the degree of Government policies and commitment for effective waste management. It was also suggested that these challenges are compounding but could be related to economic, technological, psychological and political factors (Abila and Kantola, 2013). One major challenge of the populace is their inability to segregate or characterized waste prior to their disposal. In the same vein when waste is piled up in dumpsites the practice of *insitu* burning becomes a rude and inappropriate option, *insitu* burning causes atmospheric pollution as the ambient air quality is impacted upon. Majority of the populace either lack or have unsafe temporary waste sanitary bin. Unsafe household waste sanitary bin obliges a good fathom for common household vectors that transmit major diseases of public health, including rats and cockroaches. Some wastes are usually not properly packaged in airtight containment and after transformation they produce foul odour.

As suggested by Suh (2001), profound analysis and subsequent comprehensive synthesis are good recipes for product delivery and service design. As such in order to ameliorate the problems associated with poor waste management, there is absolute need to apply the right approach. Abila and Kantola (2013), criticize the fruitless and resource consuming push-style design and suggested two basic approaches, which are focused on product design and knowledge-management solutions. For effective and sustainable management of MSW there is the need to involve all stakeholder in order to place value the adverse effects of poor waste management and effective legislation to will prohibit precarious dumping of waste as well as effective recycling aimed at economic impact such as the waste to wealth policies which aims at reducing, re-using and recycling waste. Also, as suggested by Ogwueleka, (2009), there is the need for Government to collaborate with research and development institutions.

CONCLUSION

This review on the environmental impacts of MSW in Nigeria revealed that, Government and all stakeholders need to show more commitment for the effective and safe management of waste stream. Unfortunately, some data emerging show values which exceed the standard regulatory limit for both air and water quality. Due to poor and inappropriate management of waste streams are often subjected to biological and physicochemical transformation, that can produce toxic leachate and foul odour that infringes on ambient air quality. Leachate from dumpsite can also contaminate the soil, which further infiltrates to contaminate ground water or transported by runoff which can be bioaccumulated by aquatic biota and other forms of biodiversity. Due to the significant impacts posed by MSWs; Government on one hand should provide recycling and treatment facilities for effective management MSWs, and effective legislation on the other hand in order to deter precarious dumping. Sensolator, the populace should be sensitized on safe and eco-beneficial management of waste including recycling, waste to wealth policy etc.

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